OBSERVATIONS OF IONOSPHERIC FINE STRUCTURE USING HEATER-INDUCED ARTIFICIAL AIRGLOW

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ABSTRACT

Knowledge of the upper atmosphere is essential to such varied applications as improving satellite communications, observing global change, flying high-altitude aircraft, and mitigating power line disruptions. The lower ionosphere is a particularly challenging region to study since it lies above the reach of airplanes and below that of satellite orbits. Fine structure has been detected in heated regions of the ionosphere above powerful HF antenna arrays by in situ rocket measurements and indirectly by scintillation and radar techniques. This fine structure can be more easily studied by ground-based optical methods. We have designed and installed a telescopic imaging and photometric system at the High Frequency Active Auroral Research Program (HAARP) antenna array in order to observe ionospheric fine structure. Located near Gakona, Alaska (62.39N, 145.15W), HAARP is the site of a 48-element, 8x6 phased antenna array with a maximum radiated power of 960 kW and a frequency span of 2.8 – 10 MHz.

The HAARP telescopic imaging system consists of a reflecting Newtonian telescope, two cooled (- 40 degrees Celsius) scientific bare CCD cameras, and a photometer. One of the CCD cameras is mounted on the telescope\'s eyepiece and has a field of view of about 0.4 degrees while the other is bore-sighted on the telescope and is used as a wide field of view camera with a field of view of about 13 degrees. Each camera is 16-bit with 512x512 pixel resolution. The entire telescopic system is aimed at magnetic zenith (along the magnetic field lines).

At 285 km altitude, the telescopic imager has a field of view of about 5 km which allows for pixel resolution of about 9 m, permitting decameter to kilometer scale observations. Gustavsson et al. [J. Geophys. Res., 2001] report observations of 5 - 15 km patchy 630.0 nm airglow structures in the first 20 s after the HF-pump at the Tromso, Norway heating facility is turned on. Large-scale (about 20 km) moving features were observed in 630.0 nm airglow data at the SURA facility [Bernhardt et al., J. Geophys. Res., 2000]. Decameter-scale structure was observed in the 557.7 nm oxygen line at Arecibo in connection with E-layer experiments [Kagan et al., Phys. Rev. Lett., 2000]. Since fairly wide field of view imagers are typically deployed in airglow campaigns, it is not known what sort of meter-scale features exist in the artificial airglow emissions. Rocket data shows that heater-induced irregularities consist of bundles of 10 m wide magnetic field-aligned filaments with a mean depletion depth of 6% [Kelley et al., J. Geophys. Res., 1995]. These bundles themselves constitute small-scale structures with widths of 1.5 - 6 km.

Thus far, we have in particular observed dramatic enhancement in airglow brightness when the HAARP heater beam is aimed along the geomagnetic field lines (15 degrees from vertical). Bright 630 nm and 557.7 nm airglow has repeatedly been observed simultaneously during F-

layer heating. Structured airglow patches are frequently observed to drift through the heater beam, especially during heating near a gyroharmonic. In the March 2004 campaign, the telescopic system observed unexpected small bright 557.7 nm airglow spots in the presence of aurora during E-layer heating transmissions. In general, optical measurements of artificial airglow reveal ionospheric fine structure, provide a means of estimating electron energy distributions, and challenge current theories on HF wave/particle interaction. Data from several campaigns will be presented and future plans will be discussed.